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a motion vector (MV) for determining motion compensation of a certain block is to be detected in a two-field interval, that is, between the M-th field and the (M−2)-th field. To simplify the explanation, of the detected motion, only motion in a vertical direction will be considered, and a pixel value at each pixel position is expressed in the same manner as that of FIG. 1.

Now consider the case of obtaining a determined value of a(M, 1). When it is assumed that the vertical component of the detected MV is 3, the determined value of move compensation of the a(M, 1) becomes the pixel value at the position of (M−2, 4). First, this pixel value is obtained from the pixel value within the (M−2)-th field. When the pixel value is to be obtained based on a weighted average, inversely proportional to a distance, from near-by pixel values, for example, the pixel value at the position of the (M−2, 4) is obtained by the following expression:

$$a(M-2,3)/2+a(M-2,5)/2$$

Next, based on the above MV, motion of the input image from the (M−1)-th field to the M-th field is calculated. The time difference between the M-th field and the (M−1)-th field is ½ of the time difference between the M-th field and the (M−2)-th field. Accordingly, this motion vector can be considered to be MV/2. Since the vertical component of the MV is now 3, the vertical component of MV/2 becomes 1.5. Accordingly, when a determined value of motion compensation of the a(M, 1) is obtained from the image in the (M−1)-th field, this becomes the pixel value at the position of (M−1, 2.5). This pixel value is obtained from a pixel value within the (M−1)-th field. When the pixel value is to be obtained by a weighted average, inversely proportional to a distance, from near-by pixel values, for example, the pixel value at the position of (M−1, 2.5) can be obtained by the following expression:

$$3*a(M-1,2)/4+a(M-1,4)/4$$

Based on the two determined values obtained above, a mean of the two determined values is obtained and the result is used as the determined value of the a(M, 1).

Although the above explains the case for determining motion compensation of an image for only the vertical component, a similar operation is also carried out for the case of determining motion compensation of an image having both vertical and horizontal components.

As described above, according to the fourth embodiment of the present invention, motion of an input image from a plurality of pieces of reference images sampled at different times according to detected motion at certain time intervals of a block unit including at least one pixel is calculated based on the above detected motion, and a pixel value at a position which has been compensated by the calculated motion portion for each reference image is calculated, so that it is possible to obtain a plurality of determined values of motion compensation from the plurality of pieces of reference images. Since a determined value of the input image is calculated from the plurality of determined values, noise can be eliminated if noise is included in the determined values, thus ensuring a determination at a high precision level, of motion compensation.

In the manner similar to the case of the first embodiment, it is also possible in the fourth embodiment to freely select the number of pieces of reference images, the positions of the reference images, the calculation method for obtaining a

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pixel value at a necessary position within each reference image, and either interpolation or extrapolation. For calculating determined values from a plurality of pixel values obtained from the respective reference images, there are other alternative methods than a simple averaging method such as a weighted average method and a method for calculating by using a coefficient of a low-pass filter. Although description has been made of the case for determining motion compensation based on a field of an interlace signed in the present embodiment, it is needless to mention that the effect of the determination does not change if a frame is used as a base or a noninterlace image is used as a base as shown in the second and third embodiments respectively.

According to the present invention, as is clear from the above-described embodiments, a time position of a reference image is corrected by using a motion vector as required so that a plurality of pieces of reference images sampled at different times according to detected motion at certain time intervals of a block unit including at least one pixel become images at times separated from the input image by the above time intervals, so that it is possible to obtain a plurality of pieces of images at positions separated by the above time intervals from the input image. By combining the plurality of pieces of images together, a reference image of high pixel density can be obtained and a pixel value at a position which has been compensated by the detected motion is calculated by using the reference image of high pixel density, so that the calculated pixel value is used as a determined value. Thus, there is an effect that it is possible to determine motion compensation of an image at a very high level of precision.

Further, according to the present invention, a vector for correcting a time position of the above reference image can be calculated based on motion detected at a certain time interval, which does not require a detection again of a motion vector for correcting the time position, so that this has an effect that motion compensation at a high precision level can be ensured. Further, since an interlace signal can be used as an input signal and a reference image can be in two fields of a certain frame, the above determination of motion compensation can be applied to a frame image, thus ensuring a determination, at a high precision level, of motion compensation based on a frame.

Further, since the same value can be used for a block of each input image among blocks of a plurality of pieces of input images, each block having its whole or part of spatial position superposed with that of the other blocks, as a move detected at a certain time interval of a block unit including at least one pixel, it is not necessary to carry out a plurality of detections of moves of many block in a plurality of input images so that there is an effect that a determination of motion compensation at a high precision level can be ensured.

We claim:

1. A method of determining motion compensation for an input image from motion vectors between the input image and a plurality of reference images, said method comprising the steps of:

(a) calculating a motion vector MV1 between the input image and one reference image of said plurality of reference images from a motion of at least one block unit at a second set time interval T_2 between the input image and said one reference image, said at least one block unit being a part of said input image and comprising a plurality of pixels;

(b) providing a motion vector MV2 between at least two reference images of the plurality of reference images at

a first set time interval T_1, which is parallel to the motion vector MV1 at the second set time interval T_2 and different in magnitude from the motion vector MV1 at the second set time interval T_2 by a value determined by $MV1 \cdot T_1/T_2$; and

(c) calculating the motion compensation of the input image from both of (i) the motion vector MV1 between the input image and said one reference image and (ii) the motion vector MV2 between the at least two reference images of the plurality of reference images.

2. A method of determining motion compensation for an input image from a motion vector between the input image and a plurality of reference images, said method comprising the steps of:

(a) detecting a motion vector MV1 between the input image and one reference image R1 of said plurality of reference images at a second set time interval T_2;

(b) providing a motion vector MV3 between the reference image R1 and another reference image R2 of said plurality of reference images at a first set time interval T_1, said motion vector MV3 being parallel to the motion vector MV1 and different in magnitude from the motion vector MV1 by a value determined by $MV1 \cdot T_1/T_2$;

(c) obtaining a motion vector MV2 between the input image and the another reference image R2 at a third set time interval T_3 from a sum of the motion vector MV1 and the motion vector MV3, and calculating respective pixels corresponding to the motion vector MV1 and the motion vector MV2 from pixels of the reference image R1 and the reference image R2 corresponding to the motion vector MV1 and the motion vector MV2 or from pixels positioned peripherally of the pixels of the reference image R1 and the reference image R2; and

(d) calculating motion-compensated pixel values from the calculated pixels of the reference images.

[3. A method of obtaining a motion-compensated image from a motion vector between the motion-compensated image and a plurality of reference images, said method comprising the steps of:

(a) obtaining a motion vector MV1 between the motion-compensated image and one reference image R1 of said plurality of reference images at a second set time interval T_2;

(b) providing a motion vector MV3 between the reference image R1 and another reference image R2 of said plurality of reference images at a first set time interval T_1, which is parallel to the motion vector MV1 and different in magnitude from the motion vector MV1 by a value determined by $MV1 \cdot T_1/T_2$;

(c) obtaining a motion vector MV2 between the motion-compensated image and said another reference image R2 at a third set time interval T_3 from a sum of the motion vector MV1 and the motion vector MV3, and calculating respective pixels corresponding to the motion vector MV1 and the motion vector MV2 from pixels of the reference image R1 and the reference image R2 corresponding to the motion vector MV1 and the motion vector MV2 or from pixels positioned peripherally of the pixels of the reference image R1 and the reference image R2; and

(d) calculating motion-compensated pixel values from the calculated pixels of the reference images to obtain the motion-compensated image.]

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4. A method in accordance with claim 1, wherein said motion vector MV1 between the input image and said one reference image of said plurality of reference images is calculated from a motion of at least one block unit at said second set time interval, said at least one block unit being a part of said input image and comprising a plurality of pixels.

5. A method in accordance with claim 2, wherein said motion vector MV1 between the input image and said one reference image of said plurality of reference images is calculated from a motion of at least one block unit at said second set time interval, said at least one block unit being a part of said input image and comprising a plurality of pixels.

6. A method in accordance with claim 2, wherein step (c) comprises obtaining said motion vector MV2 from a mean of said motion vector MV1 and said motion vector MV3, and said pixels positioned peripherally are valued in accordance with an average weighting inversely proportional to distance from pixels of the reference image R1 and the reference image R2.

7. A method of obtaining motion compensation for an input image, said method comprising the steps of:
(a) obtaining a first motion vector MV1 between the input image and one reference image R1 of a plurality of reference images at a second set time interval T2 between the input image and said one reference image R1;
(b) calculating a second motion vector MV2 between the input image and another reference image R2 of said plurality of reference images at a first set time interval T1 between the input image and said another reference image R2, said second motion vector MV2 being parallel to said first motion vector MV1 and having a magnitude satisfying the relation $MV2 = MV1 \cdot (T1/T2)$;
(c) calculating pixel values of said one reference image R1 from pixels at positions corresponding to said first motion vector MV1 and calculating pixel values of said another reference image R2 from pixels at positions corresponding to said second motion vector MV2, wherein said reference images R1 and R2 are such that a motion vector MV3 between said reference images R1 and R2 has a mathematical relationship with said first and second motion vectors MV1 and MV2 in which said motion vector MV3 is parallel to and different in

value from each of said first and second motion vectors MV1 and MV2; and
(d) calculating said motion compensation of said input image from said pixel values calculated in step (c).

8. A method of obtaining motion compensation for an input image, said method comprising the steps of:
(a) obtaining a first motion vector MV1 between the input image and one reference image R1 of a plurality of reference images at a second set time interval T2 between the input image and said one reference image R1;
(b) calculating a second motion vector MV2 between the input image and another reference image R2 of said plurality of reference images at a first set time interval T1 between the input image and said another reference image R2, said second motion vector MV2 being parallel to said first motion vector MV1 and having a magnitude satisfying the relation $MV2 = MV1 \cdot (T1/T2)$;
(c) calculating pixel values of said one reference image R1 from pixels at positions corresponding to said first motion vector MV1 and calculating pixel values of said another reference image R2 from pixels at positions corresponding to said second motion vector MV2, wherein said reference images R1 and R2 are previous to said input image in a time sequence; and
(d) calculating said motion compensation of said input image from said pixel values calculated in step (c).

9. A method of obtaining motion compensation for an input image, said method comprising the steps of:
(a) obtaining a first motion vector MV1 between the input image and one reference image R1 of a plurality of reference images at a second set time interval T2 between the input image and said one reference image R1;
(b) calculating a second motion vector MV2 between the input image and another reference image R2 of said plurality of reference images at a first set time interval T1 between the input image and said another reference image R2, said second motion vector MV2 being parallel to said first motion vector MV1 and having a magnitude satisfying the relation $MV2 = MV1 \cdot (T1/T2)$;
(c) calculating first pixel values of said one reference image R1 from pixels which are neighbors

of positions corresponding to said first motion vector MV1 and calculating second pixel values of said another reference image R2 from pixels which are neighbors of positions corresponding to said second motion vector MV2, wherein said reference images R1 and R2 are such that a motion vector MV3 between said reference images R1 and R2 has a mathematical relationship with said first and second motion vectors MV1 and MV2 in which said motion vector MV3 is parallel to and different in value from each of said first and second motion vectors MV1 and MV2; and

(d) calculating said motion compensation of said input image from said first and second pixel values calculated in step (c).

10. A method of obtaining motion compensation for an input image, said method comprising the steps of:

(a) obtaining a first motion vector MV1 between the input image and one reference image R1 of a plurality of reference images at a second set time interval T2 between the input image and said one reference image R1;

(b) calculating a second motion vector MV2 between the input image and another reference image R2 of said plurality of reference images at a first set time interval T1 between the input image and said another reference image R2, said second motion vector MV2 being parallel to said first motion vector MV1 and having a magnitude satisfying the relation MV2=MV1·(T1/T2);

(c) calculating first pixel values of said one reference image R1 from pixels which are neighbors of positions corresponding to said first motion vector MV1 and calculating second pixel values of said another reference image R2 from pixels which are neighbors of positions corresponding to said second motion vector MV2, wherein said reference images R1 and R2 are previous to said input image in a time sequence; and

(d) calculating said motion compensation of said input image from said first and second pixel values calculated in step (c).

11. A method in accordance with claim 7, wherein said reference images R1 and R2 are previous to said input image in a time sequence.

12. A method in accordance with claim 9, wherein said reference images R1 and R2 are previous to said input image in a time sequence.